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Enhancing the energy resolution of resonant coherent excitation using the cooled U^{89+} beam extracted from the ESR

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Synopsis We report on the resonant coherent excitation (RCE) of the $2s$-$2p_{3/2}$ transition in Li-like U^{89+} with an enhanced energy resolution, which was achieved by reducing the projectiles momentum spread. The kinetic temperature of the beam was decreased by electron cooling in the ESR, and the collisional momentum broadening in the target was suppressed by the use of thin crystal (1.0 and 2.5 μm-thick). The resonance width was observed to be ∼1.4 eV in FWHM, which is three-times narrower than that from the previous work.

Energetic ions traveling through a crystalline target can be resonantly excited through the interaction with the periodic crystal field. This process is called resonant coherent excitation (RCE), and expected to be a versatile tool in the atomic physics experiments in the short wavelength regime. Towards the high-resolution spectroscopy of highly-charged heavy ions, we have recently demonstrated the experimental proof-of-principle of the RCE of high-Z ions using a 7 μm-thick Si crystal and the 190 MeV/u Li-like U^{89+} beam from the SIS at GSI [1]. The RCE of $2s$-$2p_{3/2}$ transition was observed under the (220) planar channeling condition at the transition energy of 4459 eV, and the resonance width (FWHM) was 4.4 eV (Figure 1(a)) . The resonance width was predominantly limited by the momentum spread of the beam, which eventually determines the energy resolution of the RCE-based spectroscopy.

In autumn 2014, we carried out an upgraded experiment dedicated to the reduction of the momentum spread of the beam. Instead of getting the U^{89+} beam directly from the SIS, an U^{90+} beam from SIS was transported to the storage ring ESR. The beam was cooled by the electron cooler in the ESR, and slowly extracted as continuous U^{89+} beam using the electron capture at the cooler. The crystal thickness was also reduced to 1.0 and 2.5 μm to suppress the momentum spread caused by collisions in the crystal.

Figure 1(b) shows the $2s$-$2p_{3/2}$ RCE spectra observed in this work, exhibiting a sharp resonance width of ∼1.4 eV. The successful reduction of the beam momentum spread led to the improvement of the energy resolution of RCE by a factor of 3. Moreover, the resonance shape observed in this work can be well fitted to a Lorentzian curve as shown in the solid curve in Figure 1(b). This allows the determination of the peak position with a significantly better accuracy.

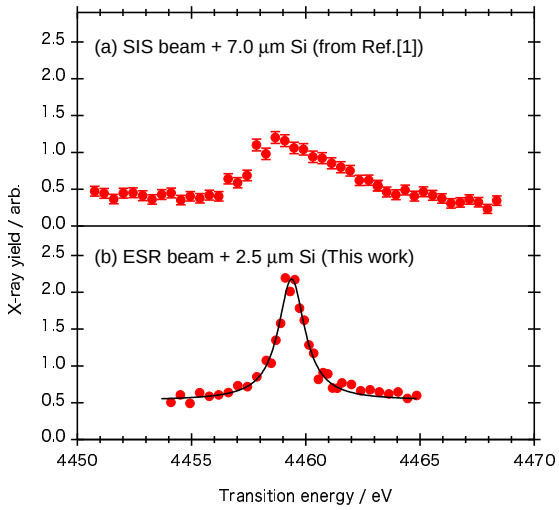

Figure 1. The RCE spectra of $2s$-$2p_{3/2}$ transition in the 190 MeV/u Li-like U^{89+} beam from (a) SIS and (b) ESR .

References

[1] Y. Nakano, Y. Takano, T. Ikeda, Y. Kanai, S. Suda, T. Azuma, H. Bräuning, A. Bräuning-Demian, D. Dauvergne, Th. Stöhlker and Y. Yamazaki, Phys. Rev. A **87** (2013) 060501(R).

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